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# Aortic Graft Infection: Is there a Place for Partial Graft Removal?

**J. P. Becquemin*, P. Qvarfordt, J. Kron, A. Cavillon, P. Desgranges, E. Allaire and D. Melliere**

*Department of Vascular Surgery, Henri Mondor Hospital, Creteil, France*

## Introduction

Aortofemoral grafts may become infected intraoperatively by direct graft contamination or postoperatively by bacteriaema or septicaemia, abscess in the vicinity of the graft and aortoenteric fistula. All causes put together, the incidence of aortofemoral graft infection is between 1 and 3%.[1] Graft infection remains a devastating complication. Mortality rates mainly due to arterial rupture or generalised sepsis with multiorgan failure varies between 8 and 43% and amputation rates between 7 and 25%.[2]

A variety of treatment strategies for aortofemoral graft infection have been proposed including conservative management, total graft excision and partial graft removal. In the two latter options the question remains open as to which type of revascularisation should be employed (*in situ* vs. extra-anatomical route) and by which conduit (autogenous vein or arteries, fresh or cryo-conserved allograft, PTFE or antibiotic bonded Dacron graft). This paper focuses on our own experience with partial graft removal as well as a literature review to define the place of this treatment in aortofemoral graft infection.

## Patients and Methods

A retrospective review was performed using our computerised database system on which data for all hospitalised patients have been stored since 1981. The records of all patients with an infected aortic or aortoiliofemoral graft were reviewed and only patients who were primarily treated by a partial graft removal were included in the present study. When recent information was missing, the patient was called for a new visit or the family, or the General Practitioner, were contacted for a telephone interview. Between 1981 and 1995, the vascular centre at Henri Mondor Hospital has treated 79 patients with aortic and aortofemoral graft infection, of whom 20 were primarily treated by a partial graft removal.

* Please address all correspondence to: J. P. Becquemin.

## Surgical Approaches

Depending on whether the site of infection was located at the abdomen or at the groin, two different surgical approaches were used for partial graft removal.

### *Abdominal infection*

Partial graft removal was used in cases of an aortoenteric fistula when the infection was apparently limited to the site of the fistula; either by a short replacement of the contaminated part of the body of the graft with a new graft segment sutured to the original one, or by removal of the body of a bifurcated graft, the distal part of the graft limbs being left in place (Fig. 1). When a new graft was placed in a potentially contaminated area, an omental flap was interposed between the graft and the surrounding tissue. Postoperatively, appropriate antibiotics were given for a period of 6 weeks.

### *Groin infection*

The infected groins were isolated with a gauze soaked with povidone iodine. Then the patient's abdomen and legs were washed with an antiseptic solution and wrapped in sterile drapes. A retroperitonal incision or a laparotomy was made to check the origin of the limb and body of the bifurcated graft. When the proximal segment of the graft was well incorporated with no signs of infection (no pathogens present on the intraoperative bacteriological examination), the proximal part of the graft was left in place and the distal part

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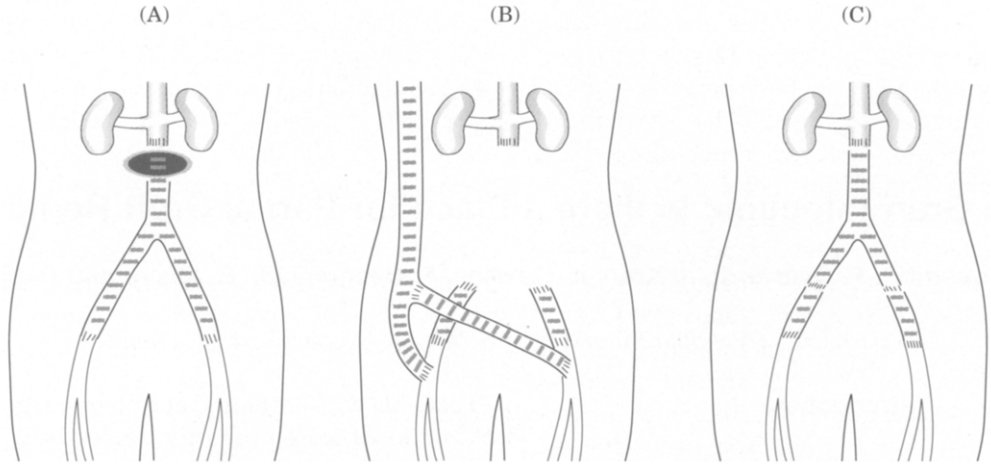


**Fig. 1.** (A) Aortic graft body infection due to aortoduodenal fistula. (B) Removal of the proximal part of a bifurcated Dacron graft and axillobifemoral bypass. (C) Removal of the distal segment of a Dacron tube graft and *in situ* repair with interposition of a new Dacron tube graft.

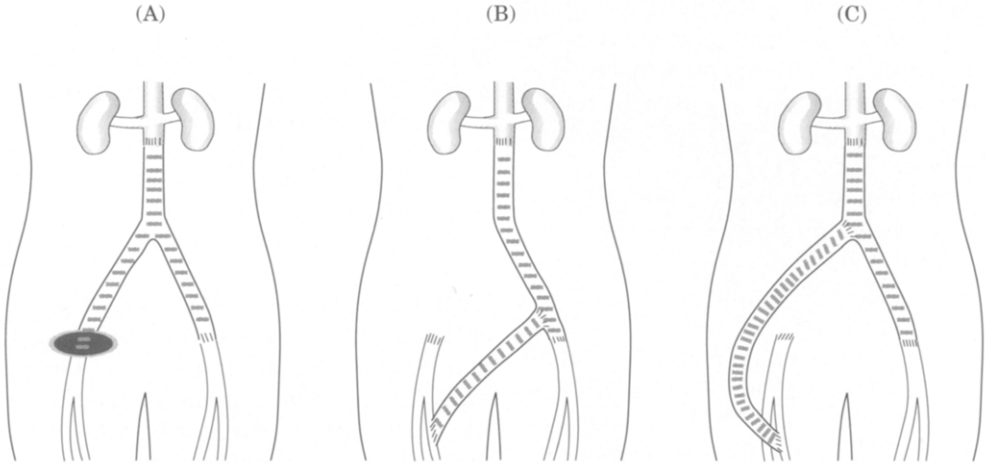


**Fig. 2.** (A) Aortic graft limb infection located at the groin. (B) Removal of the infected graft limb of the original graft and revascularisation from the contralateral graft limb via an extra-anatomical route. (C) Revascularisation from the origin of the graft limb, to the femoral artery. The new graft is tunnelled above the iliac bone.

of the non-infected graft segment was dissected free for a few centimetres. When no revascularisation was considered necessary, the proximal part of the non-infected graft was ligated and the distal graft limb containing the segment where infection was thought to be localised was excised and the wound closed. When a revascularisation was required the donor and recipient arteries were chosen according to the extent and localisation of the infection, the distal run-off and the route of the new graft. The donor site was either the original non-infected proximal graft, or the contralateral graft limb or artery, or the axillary artery. The recipient artery was either the deep femoral or the superficial femoral, or the popliteal artery (Fig. 2). All efforts were made to place the new anastomoses in a non-infected area and the new graft was tunnelled through a non-infected field. In case of low virulent infection, the infected part of the graft was removed, all contaminated tissue debrided and the new graft was placed *in situ*. The new anastomoses were performed in a non-infected area and the wound closed without drainage. The wounds were then protected by sterile dressings. Thereafter, the infected area was opened, debrided and the infected graft segment removed. Distal arteries were closed with monofilament polypropylene suture and covered by reattaching a well vascularised tissue surrounding. Subcutaneous tissue and skin was left opened with wet dressing changes.

## Results

Between 1981 and 1995, 20 patients were treated at our institution with a partial graft removal for aortic

graft infection. There were 19 males and one female with a mean age of 64.8 years ± 12 years, ranging from 52 to 82 years. Nine of these patients had had the original operation at our centre, the remaining 11 patients were referred from other institutions. The frequency of aortic and aortofemoral graft infections at our institution is less than 1%. The primary operation was performed for atherosclerotic occlusive disease in 13 patients, abdominal aortic aneurysm in three, radiotherapy-induced arterial occlusive disease in three, and congenital hypoplasia in one. The graft material was Dacron in 19 and PTFE in one. There was one aortoaortic tube graft, 18 aortobifemoral grafts and one aortounifemoral graft. The mean interval between the first operation and the diagnosis of graft infection was 3.42 years, ranging from 2 months to 13 years.

Presenting symptoms included groin infection with a false aneurysm in eight cases, groin infection or haemorrhage in eight cases, gastrointestinal haemorrhage in three patients with aortoduodenal fistula, and septic embolism to the foot in one. Except in two cases of acute haemorrhage in two patients with groin infection requiring an emergent operation, all patients underwent preoperative angiography to assess the anatomy and patency of inflow and outflow vessels, and the type of aortic and femoral anastomosis (end-to-end or end-to-side). Angiography was also useful to rule out an anastomotic false aneurysm. Abdominal and groin CT scans were also routinely done to investigate the perigraft tissue. Fistulography was obtained in two cases and Gallium scintigraphy in one case. In none of the 20 patients included in this series were there radiological signs of propagation of the infection to the entire graft.

Pathogens were identified from bacterial culture of perigraft fluid, if present, and from the graft and surrounding tissue. There were 12 positive cultures including *Staphylococcus epidermidis* in eight and multiresistant *Staphylococcus aureus* in four. Colibacillus were found in three cases and proteus in one. In four cases no pathogen could be identified by the bacteriological study.

The three patients with an aortoduodenal fistula had an infection limited to the body of the graft. Partial removal of the graft was performed in all three. In two cases, only the proximal part of the aortobifemoral graft was removed. The aortic stump was closed in two layers, after debridement of the anastomotic line. The revascularisation was performed in one of these cases by an axillobifemoral bypass and in the other case by an *in situ* bifurcated rifampicin-bonded Dacron graft, the limbs of the new graft being sutured to the limbs of the old graft (Fig. 1). In the third patient there was a false aneurysm, including the distal suture line of a Dacron tube graft. The fistula was closed, the false aneurysm resected and the dehiscence between the old graft and the aortic wall was closed with a cryopreserved allograft patch. The early postoperative course of the three patients were uneventful. However, after 12 months the patient treated with an axillobifemoral bypass graft died suddenly, probably from an aortic stump rupture. The patient treated *in situ* with a rifampicin Dacron graft thrombosed one graft limb at 3 months. He was reoperated on, and the original and new graft were completely removed and replaced by an *in situ* cryopreserved bifurcated arterial graft. He was well and alive after 8 months. The third patient developed a new false aneurysm of the distal aortic anastomosis and was reoperated upon after 22 months. The old graft was entirely removed and replaced by a standard Dacron tube graft *in situ*. He was well 12 months after the latest operation.

Seventeen patients had a unilateral graft limb infection. In four cases no revascularisation was attempted after partial graft removal, as the grafts were thrombosed without limb-threatening ischaemia. In the remaining 13 cases various routes and grafts were used. Four axillofemoral and two axillopopliteal bypasses were performed using PTFE. In two cases, a cryopreserved arterial allograft was anastomosed from the original graft to the superficial femoral artery and placed *in situ*. One patient had a PTFE graft placed *in situ* between the original graft and the popliteal artery. In another case, the PTFE graft was tunnelled above the iliac bone and anastomosed proximally to the original graft and distally to the femoral artery. An obturator bypass was performed in two cases (one vein, one PTFE) and in the remaining case a femorofemoral PTFE cross-over graft was performed.

Among the 17 patients with a distal limb graft infection, in the postoperative follow-up four patients died (23%). Three of them had a persistant sepsis and died of multiple organ failure despite reoperation to remove the old graft entirely. One patient died of myocardial infarction. Two of these patients were also amputated at the high level. Among the 13 surviving patients, five required reoperation, for persistent graft infection in four and for an acute limb graft thrombosis in one. This latter patient eventually required amputation. Eight patients were alive without amputation, without reoperation and with no evidence of infection. Six of these eight patients had an *S. epidermidis* infection, and in two no pathogen was found. The entire follow-up period ranged from 3 months to 13 years, mean 3.4 years.

Of the four patients with persistent infection that underwent a secondary operation for total graft removal, none had evidence of infection during follow-up. In two patients, these grafts occluded at 6 and 13 months (one of these patients had to be amputated at 15 months). One other patient died of myocardial infarction after 5 years. Only one patient was alive and well during long-term follow-up. In eight patients with a primary successful partial graft removal, no signs of infection were observed during the follow-up, but five late graft occlusions occurred, leading to amputation in four cases. There were four deaths, three from a myocardial infarction and one from stroke. Three patients were still alive and well at 6, 12 and 23 months postoperatively.

## Discussion

Total graft excision, aortic stump ligature and axillofemoral revascularisation remains the "gold standard" in the treatment of an aortic graft infection in spite of its high mortality and morbidity. In patients with a localised graft infection, partial graft removal is an attractive alternative because of its relative simplicity and some encouraging reports of improved early results compared with the more radical classical treatment. However, it carries a lot of uncertainty because it is impossible to be sure that the graft left in place is sterile and will not be contaminated by adjacent infected tissue or by an ascending infection via lymph nodes. In the present series, 35% of our patients had persistent infection after partial graft removal. Preoperative diagnostic measures are necessary to verify clinically obvious cases of extensive infection, e.g. multiple false aneurysms present on arteriogram or CT scan in a patient with groin sepsis and fever. However, in most cases of aortic graft infection, including the present study, neither angiogram nor CT scan are accurate enough to ascertain that the infection is limited to a part of the graft. As we had no experience of indium 111 scintigraphy, operative exploration of the presumed non-infected part of the graft remained the only way to rule out diffuse graft infection. A well incorporated graft is an excellent sign of the absence of infection. Unfortunately, there are difficult situations where, even at surgical exploration, the extent of infection remains uncertain. This is especially when the graft is poorly healed as can often be the case in early graft infection, or with woven Dacron grafts, or with low virulent pathogens, notably *S. epidermidis*, causing a "microfilm" infection restricted to the graft which can be missed by the routine intraoperative bacteriological examination. Thus, a limited procedure for graft infection may predispose to re-explorations, redo surgery or catastrophic events if the infection persists.

In our series, the results of partial graft removal were not very encouraging. When graft body and limb graft infections were pooled, we observed a perioperative mortality of 20%, an amputation rate of 15%, and redo surgery for a persistent infection in 35% of the cases. Of the 20 patients only 11 (55%) had good perioperative results. Bunt[2] reported compiled data of 106 attempts at partial excision. He noted 20 deaths (19%), 20 amputations (20%) and 47 recurrences of infection (44%), and he concluded that the procedure was unsafe, being successful in only one-third of the cases. However, few series have extensive experience, and results from one series to another are not uniform. This may be due to differences in patient selection or in procedures used. Failure was reported in 4/4 cases by Fulenwider *et al.*[3] and 5/5 cases by Yeager *et al.*,[4] Some better results were reported by others. Lorentzen *et al.*,[1] in a multicentric study of 62 infected aortic grafts, reported 21 attempts at partial excision with 10 failures, two deaths and six amputations. Edwards *et al.*[5] found four successes out of eight cases and Ricotta *et al.*[6] nine out of 12 cases. Reilly *et al.*[7] described partial graft removal in 23 patients. One-third died of persistent infection or aortic stump rupture, one-third survived but required a redo operation with total graft removal, and the remaining third (33%) did well and were apparently cured. In these series, better results were obtained with total graft removal, but it is difficult to draw any safe conclusions regarding the selection of patients who might benefit from a partial graft removal.

The best results of partial graft removal, in the literature as well as in our experience, have been obtained in patients with a low virulent bacterial infection, most frequently *Staphylococcus epidermidis*. Bandyk *et al.*[8] successfully treated 14 aortofemoral groin infection, 11 of whom were due to *S. epidermidis* with partial graft removal and PTFE *in situ* graft replacement. He had no failure, neither death, nor amputation in the early postoperative period. During follow-up (mean 21 months), three patients died of unrelated causes and none had recurrent infection or arterial complication. Towne *et al.*[9] attempted a femoral graft limb excision and interposition with an *in situ* PTFE graft in 14 aortobifemoral graft infections associated with positive culture for *S. epidermidis*. The grafts were covered with a gracilis or sartorius muscle flap whenever possible. At an average follow-up of 39 months no patient had died of graft failure or infection. However, two patients had persistent infection of the intra-abdominal portion of the graft, which had not previously been resected.

Calligaro *et al.*[10] attempted subtotal graft excision in 43 cases of a series of 120 graft infections (including aortic and peripheral grafts). In case of graft occlusion, an oversewn graft segment of 2–3 mm was left remnant at the anastomosis to maintain patency of the artery. Wound healing was observed in 35 cases (85%). Eight failures were due to persistent infection including delayed anastomotic bleeding at the sites of prosthetic patches. Two patients died and nine were amputated. In Calligaro's series, graft preservation was obtained with both Gram-negative and Gram-positive bacteria with the exception of pseudomonas. In a canine model, Geary *et al.*[11] also showed that pseudomonas could disrupt native arteries. Miller, in a series of 20 patients, described a subgroup of 15 aortofemoral Dacron graft infections.[12] Ten grafts were partially removed with a good outcome in seven. Three patients had persistent sepsis, there were two deaths but no amputation after a mean follow-up of 45 months. In his series Miller reported multiresistant *S. aureus* or pseudomonas in four out of the 20.

The type of grafts employed for the revascularisation after removal of an infected graft is thought to be important. *In vitro*, bacterial adherence to prostheses varies with the pathogens and with prosthetic graft materials.[13] In humans, good results have been obtained with autologous veins and arteries.[7,14] In the absence of available autologous grafts, PTFE grafts may constitute a reasonable alternative, since this material appears to be less prone to bacterial adherence than Dacron.[13] The excellent results of Bandyk *et al.*[8] and Towne *et al.*[9] were obtained with PTFE grafts. Rifampicin-bonded Dacron grafts have been associated with good results in animal models[15] and in some sporadic clinical cases.[16] Rifampicin may be of value against low virulent bacteria but the protective effect of rifampicin-bonded grafts is limited to 5–10 days and bacterial cultures are increasingly resistant to rifampicin. Excellent results have been published with fresh arterial allografts.[17] Our limited experience consists of the two cryopreserved allografts after partial graft removal, both of which failed.

The consequences of a failed attempt of partial graft removal must be analysed. In the series of Fulenwider *et al.*,[3] all patients with an infected graft but without fistula survived the second operation. Reilly *et al.*[7] found that eight patients with a recurrent infection were successfully treated and that the attempt at partial removal did not threaten either life or limb. Gordon *et al.*[18] attempted minimal graft excision in four of 15 patients, two of whom required a subsequent total graft excision, but all four patients remained cured. In our series we did not observe such favourable results as 3/8 patients, where a partial graft removal failed, died in the early postoperative period. In our opinion, partial graft removal should be attempted only when there is a high probability of success and not just as a way of performing a less extensive operation in a poor risk patient, in which case total graft excision or conservative treatment is probably a better option.

## Conclusion

Partial graft removal appears to be a less than optimal method, despite some reports of long-lasting success, the failure rate when secondary operation is taken into account may be as high as 60%. In our series the perioperative mortality and morbidity rates was 45%. Nevertheless, partial graft removal may be attempted in a very selected subset of patients under the following conditions.

1. Infection limited to a portion of the graft. This carries the problem of the diagnosis of the extent of infection. The only certain diagnostic remains operative exploration and bacteriological examination of the segment of the graft contiguous with the graft left in place.
2. Infection caused by low virulent bacteria. The best results have been obtained in infection due to *S. epidermidis*.
3. Revascularisation carried out either *in situ*, in case of low virulent infection, or via a non-contaminated field, usually by an extra-anatomic procedure in case of virulent infection.
4. New anastomoses placed in a non-infected field with coverage by omentum or muscle flap.
5. Conduit made of autologous tissue or PTFE/rifampicin-soaked Dacron if prosthetic material must be used.
6. Appropriate antibiotics given for a period of at least 6 weeks.
7. Long-term surveillance in order to detect persistent or new graft infection.

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